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The Relationship between Household Expenditures and Environmental Impacts

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Abstract

Supporting the lifestyles of households requires goods and services, which are interrelated with environmental degradation. Analysis of environmental impacts of different household types may provide insight into more sustainable consumption patterns. In this paper we evaluate the relationship between Dutch household expenditures and multiple environmental impact categories, including climate change, acidification, eutrophication and smog formation, for the year 2000. We combined environmentally extended input-output analysis with household expenditure data. Additionally, we used the concept of elasticity to determine the relationship between expenditures and environmental impacts. Our results show that the environmental impacts of all four impact categories increase with increasing expenditures, although the degree to which the environmental impact increases differs per impact category. Climate change and eutrophication increase less than proportionally with increasing expenditures. Acidification increases nearly proportional with increasing expenditures, whereas smog formation increases more than proportionally.

Keywords: households, consumption pattern, environmental impact, elasticity, The Netherlands.

1. Introduction

Households consume goods and services, which are interrelated with environmental degradation. Analysis of environmental impacts of different household types may provide insight into more sustainable consumption patterns. Since the 1970s, the energy requirements of various household types have been extensively analyzed by combining energy input-output analysis with household expenditure data (Herendeen and Tanaka, 1976; Herendeen, 1978; Vringer and Blok, 1995; Lenzen *et al.*, 2004). The environmental impacts related to household consumption, however, remained underexposed. Recent studies have quantified the environmental impacts of goods and services, covering total societal consumption (for an overview of these studies see Tukker and Jansen, 2006). The results of these studies offer possibilities for analyzing the relationship between household characteristics and environmental impacts.

The aim of this paper is to evaluate the relationship between household expenditures and multiple environmental impact categories, including climate change, acidification, eutrophication and smog formation. We start with explaining the method that we have used in our study, which is environmentally extended input-output analysis (Section 2). Then, we present the relationship between household expenditures and environmental impacts in the results section (Section 3). Finally, we briefly discuss the results (Section 4) and draw conclusions (Section 5).

2. Method

To quantify the environmental impacts of households, we first determined the environmental impact intensities of goods and services. We then combined these intensities with data on household expenditures.

2.1 Input-output analysis

By using the method of Nijdam *et al.* (2005), we quantified the environmental impact intensities of 365 categories of goods and services, which cover all Dutch private consumption in 2000. In contrast to Nijdam *et al.* (2005), we assumed that the technological matrix of foreign countries is similar to the Dutch technological matrix. This assumption will affect the environmental impact intensities of certain expenditure categories, because some production processes in foreign countries deviate from those in the Netherlands. Though, we do not expect systematic effects.

The total emission intensity of aggregate product group p, e_p^{tot} (expressed in kg emission equivalent per Euro of product value) is the sum of the direct and indirect emission intensity:

$$e_p^{tot} = e_p^{dir} + e_p^{ind} \quad \mathbf{(1)}$$

where e_p^{dir} represents the direct emission intensity of product group p, and e_p^{ind} represents the indirect emission intensity of product group p (both expressed in kg emission equivalent per Euro of product value).

The direct emission intensities, e_p^{dir}, were determined by screening all consumer products individually. The indirect emission intensities were calculated with:

$$\mathbf{e}^{\mathbf{ind}} = \mathbf{d}\,(\mathbf{I} - \mathbf{A})^{-1}\mathbf{S} \quad \mathbf{(2)}$$

where $\mathbf{e}^{\mathbf{ind}}$ is a 1 × 365 vector containing the indirect emission intensities of product groups (kg emission equivalent per Euro of product value); **d**, a 1 × 112 vector of emissions (kg) per unit of output (Euro) in 112 sectors; $(\mathbf{I} - \mathbf{A})^{-1}$, the 112 × 112 Leontief inverse matrix of the Netherlands inclusive foreign production, with **A** as a 112 × 112 matrix of input–output coefficients based on intersectoral commodity flows, and **I**, an identity matrix. Here **S** is a 112 × 365 matrix with supply coefficients describing the supply of 112 Dutch and foreign industry sectors to 365 product groups purchased by Dutch consumers. Supply coefficients are expressed as supply of a sector to one product group per total supply to that particular product group (Euro per Euro).

2.2 Household expenditures

Data on household expenditures were derived from the Dutch expenditure survey of 2000 (Statistics Netherlands, 2001). By multiplying the emission intensities with household expenditures, we obtained the household environmental impact for each household in the budget survey. Household expenditures have been adjusted for differences in household size and composition, by applying a scale of consumer units (C.U.) as defined by Statistics Netherlands (Schiepers and Kickken, 1998). The quantity of environmental impact per consumer unit i, Q_i^{tot} (expressed in kg emission equivalent) can be calculated as follows:

$$Q_i^{tot} = \sum_p e_p^{tot} M_{p,i} \quad \mathbf{(3)}$$

where e_p^{tot} is the total emission intensity of aggregate product group p (kg emission equivalent per Euro of product value) and $M_{p,i}$, represents the total annual expenditures of consumer unit i on product group p (Euro).

2.3 Correlation analysis of expenditures and environmental impacts

We used the concept of elasticity to evaluate the relationship between expenditures and environmental impacts. The expenditure elasticity η represents the percentage change in the quantity environmental impact, Q, resulting from a 1 percent increase in the annual equivalent household expenditures[1], M. The expenditure elasticity η for environmental impact, Q, is defined as:

$$\eta = (\delta Q/\delta M)/(Q/M) \quad \mathbf{(4)}$$

The elasticity η can be calculated by regressing the environmental impact data as a function:

$$Q = kM^{\eta} \quad \mathbf{(5)}$$

[1] Equivalent household expenditures refer to household expenditures corrected for size and composition of the household.

Where k and η are constant.

3. Results

3.1 Expenditure elasticities

Table 1 shows the expenditure elasticities for the environmental impact categories climate change, acidification, eutrophication and smog formation. Environmental impacts increase with increasing equivalent household expenditures (elasticity > 0), although, the degree to which environmental impacts increase differs. Climate change has an expenditure elasticity of 0.84, which means that GHG requirements increase by 0.84 percent when expenditures increase by 1 percent. Thus, with increasing expenditures the consumption pattern changes in such a way that GHG requirements saturate slightly. Eutrophication has an expenditure elasticity of 0.81, which is slightly lower than the elasticity of climate change. Acidification has an expenditure elasticity of 0.96, implying that acidification increases nearly proportional with increasing expenditures. In contrast, smog formation has an expenditure elasticity of 1.42, implying that smog formation increases more than proportional with increasing expenditures.

Table 1

3.2 Product group breakdown

Household environmental impacts can be broken down into product groups. We present the results at the level of five aggregate product groups. The product group ‘food’ comprises all kinds of food products including outdoor consumption. ‘House’ consists of rent or mortgage, room heating and lighting, maintenance of the house, furniture, household appliances, and the like. ‘Clothing and footwear’ comprises purchase and repair of clothing and footwear. The product group ‘hygiene and medical care’ includes personal care, medical care and cleaning equipment. ‘Development, leisure and traffic’ contains education, holidays, public transport, private transport, motor fuels, and the like.

The relative importance of the product groups differs considerably per impact category. Climate change is mainly the result of GHG emissions from ‘food’, ‘house’ and ‘development, leisure and traffic’. Acidification mainly originates from emissions from ‘food’ and ‘development, leisure and traffic’. Eutrophication mainly results from emissions from ‘food’, while smog formation mainly originates from ‘development, leisure and traffic’ (for further information on the environmental impacts of products and services see Nijdam *et al.*, 2005; Tukker, 2006). Additionally, the relative importance of the product groups differs per equivalent expenditure decile, due to changing consumption patterns. With increasing expenditures, the share of emissions from ‘development, leisure and traffic’ generally increases, for example.

Figure 1, 2, 3 and 4

Each environmental impact arises from the consumption of a mix of goods and services. The different contribution of product groups to each impact category explains the different values of the expenditure elasticities in Section 3.1. Eutrophication is predominantly caused by food consumption. Since food is a necessity, expenditures on food increase less than proportionally with expenditures. As a consequence, the expenditure elasticity of eutrophication is low as compared to the expenditure elasticities of the other impact categories. Smog formation has a high expenditure elasticity, because it mainly arises from luxury goods like gasoline and holidays. Acidification is related to the consumption of a mix of necessities and luxuries, namely 'food' and gasoline, resulting in a nearly proportional increase of this impact category with increasing expenditures. Climate change is also related to the consumption of a mix of necessities and luxuries; however, the share of GHG emissions from necessities, such as gas and electricity, is larger than the share of GHG emissions from luxuries, such as gasoline and holidays, resulting in a less than proportional increase in climate change with increasing expenditures.

4. Discussion

Several aspects may have influenced the results in this study. The input–output method is a top-down technique that assumes homogeneous industry sectors regarding their product range. However, some variety may exist in the product range, which can lead to incorrect allocations of emissions to product groups. We are aware that this may have affected the emission intensities of product groups in our study. Therefore, we presented the results at the level of five aggregate product groups diminishing possibly incorrect allocations of emissions. Additionally, we assumed that the emission intensity value per product group (at the level of 365 product groups) is the same for all expenditure levels. This implies that a sweater of 60 Euro causes twice the emissions of a sweater of 30 Euro. However, this assumption ignores the fact that some expensive products involve a large portion of manual labour, which has a lower emission intensity. Since, households with high expenditure levels probably purchase more expensive products than households with lower expenditure levels, the elasticities are likely to be smaller than calculated in our study.

5. Conclusion

Climate change, acidification, eutrophication and smog formation increase with increasing household expenditures, although the degree to which the environmental impacts increase depends on the impact category. We found that climate change and eutrophication increase less than proportionally with increasing expenditures. Acidification increases nearly proportional with increasing expenditures, whereas smog formation increases more than proportionally. The relationship depends on the mix of necessities and luxury goods that give rise to the environmental impact category.

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Table 1. Expenditure elasticities of four environmental impact categories, The Netherlands 2000

	Expenditure elasticity	Parameter confidence interval (95%)	T	R^2
Climate change	0.84	+/- 0.0095	88.17	0.77
Acidification	0.96	+/- 0.0134	71.52	0.68
Eutrophication	0.81	+/- 0.0191	42.62	0.43
Smog formation	1.42	+/- 0.0271	52.25	0.53

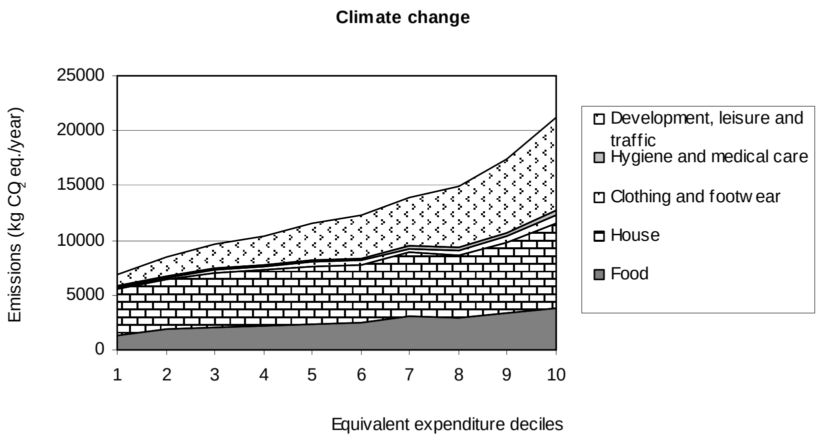

Fig. 1. Climate change: emissions of five product groups by equivalent expenditure decile, The Netherlands 2000.

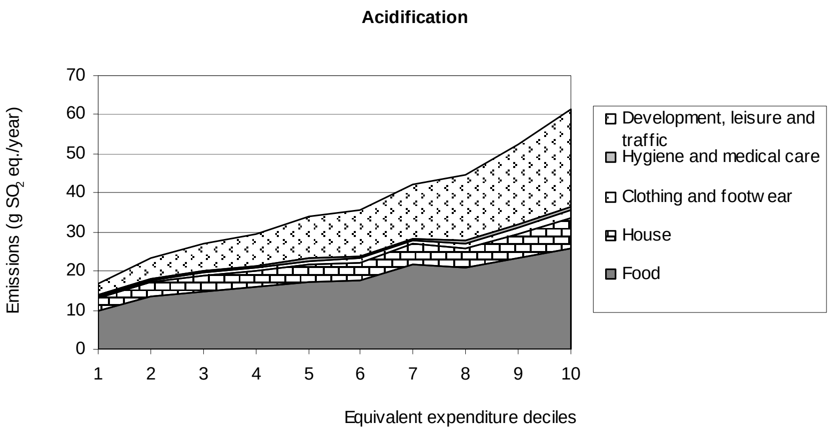

Fig. 2. Acidification: emissions of five product groups by equivalent expenditure decile, The Netherlands 2000.

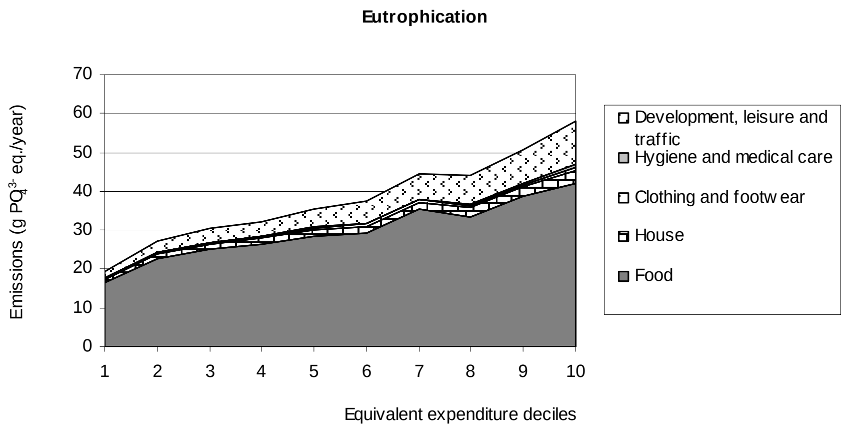

Fig. 3. Eutrophication: emissions of five product groups by equivalent expenditure decile, The Netherlands 2000.

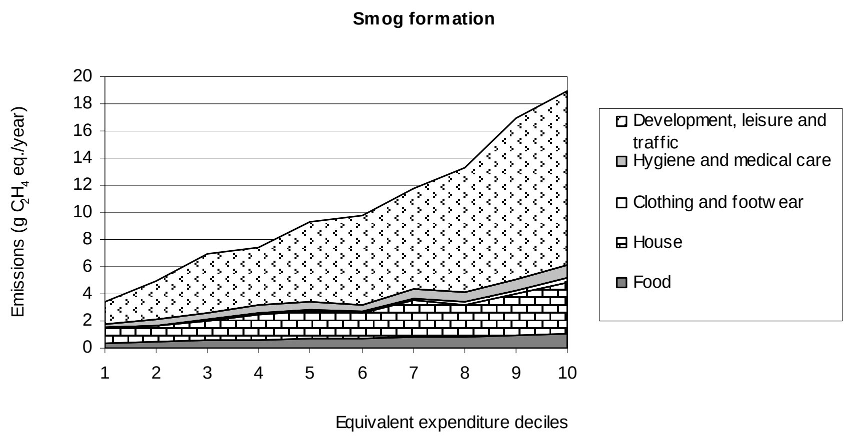

Fig. 4. Smog formation: emissions of five product groups by equivalent expenditure decile, The Netherlands 2000.